Missouri Department of Natural Resources

Biological Assessment and Habitat Study Report

Sandy Creek
Putnam County

September 2007 – April 2008

Prepared for:

Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Control Branch

Prepared by:

Missouri Department of Natural Resources
Field Services Division
Environmental Services Program
Water Quality Monitoring Section

Table of Contents

Tables

Attachments

1.0 Introduction

At the request of the Water Protection Program (**WPP**), the Environmental Services Program's (**ESP**) Water Quality Monitoring Section (**WQMS**) conducted a biological and habitat assessment of Sandy Creek. Sandy Creek flows through a rural watershed in Putnam County in northern Missouri.

On the 2002 303(d) list, the entire 3-mile class-C section of Sandy Creek was listed as impaired for unknown pollutant(s) and unknown source(s) by the U. S. Environmental Protection Agency (**USEPA**). A total of nine Missouri streams are listed by USEPA for unknown pollutants and sources. No specific reason is given for listing Sandy Creek.

On July 24, 2007 a study plan was submitted to the WPP (Appendix A). See Section 1.4 for the null hypotheses stated in the study plan. Null hypotheses for biological and habitat assessments are included in the plan.

1.1 Purpose

The purpose of this study was to determine if the Sandy Creek macroinvertebrate community and/or stream habitat were impaired and, if so, determine the possible causes.

1.2 Objectives

- Determine if the macroinvertebrate community of Sandy Creek is impaired.
- Determine the habitat characteristics of Sandy Creek.
- Define the water quality characteristics of Sandy Creek.

1.3 Tasks

- Conduct a biological assessment of the macroinvertebrate community of Sandy Creek.
- Conduct a habitat assessment of Sandy Creek.
- Conduct a water quality assessment of Sandy Creek.

1.4 Null Hypotheses

- Macroinvertebrate assemblages are similar between Sandy Creek and biocriteria reference (**BIOREF**) streams.
- Macroinvertebrate assemblages are similar among Sandy Creek stream segments.
- Macroinvertebrate assemblages will not differ significantly between the two sample seasons.
- Habitat quality is similar among Sandy Creek stream segments.
- Habitat quality is similar between Sandy Creek and biocriteria reference streams.

2.0 Study Area

Sandy Creek originates just south of the town of Mendota. It flows southeast through its rural watershed of grassland, forest, and cropland (Table 2) until its confluence with Shoal Creek northwest of Glendale.

According to Chapter 7 of the State Water Quality Standards, 10 CSR 20-7.031 (MDNR 2005b) a 3-mile segment of Sandy Creek is designated class "C". That segment begins at sec. 19, T. 66 N., R. 17 W. and ends at the confluence with Shoal Creek at NW ¼ NE ¼ sec. 28, T. 66 N., R. 17 W. Beneficial use designations are for livestock and wildlife watering, protection of warm water aquatic life, human health—fish consumption, and whole body contact recreation B.

Sandy Creek is located within the Central Plains/Grand/Chariton Ecological Drainage Unit (**EDU**). An EDU is a region in which biological communities and habitat conditions can be expected to be similar. See Appendix B for a map of EDUs and the 14-digit Hydrologic Units (**HU**) that contain the sampling reaches for Sandy Creek. See Table 2 for a comparison of land use for the EDU and the 14-digit HUs.

2.1 Water Quality Concerns

Agricultural activity dominates the landscape in northern Missouri, including the Sandy Creek basin. This includes row crops and cattle pasture as well as confined animal feeding operations (**CAFO**). Erosion of agricultural land is a major cause of sediment contribution to northern Missouri streams. Oftentimes row crops are planted to the edge of stream banks, thus eliminating stabilizing riparian vegetation. This causes the banks to become unstable, steep, and without shade resulting in higher summer water temperatures and loss of habitat.

Historic coal mining was an activity that may affect the watershed in Sandy Creek, as well as other parts of northern and western Missouri. Coal mining in northern Missouri, including the Sandy Creek watershed, has ceased. The most recent mining occurred in the Sandy Creek watershed in the early to mid 1990s. The formerly coal mined land in the Sandy Creek watershed has either been reclaimed or is in the final stages of reclamation. Mining in the Sandy Creek watershed was extensive. It was conducted up to and along the stream bank for a considerable distance, starting at the most upstream sample station and continuing upstream along the northeast bank (personal communication, MDNR Land Reclamation Program, Jan. 2009). Not only can coal mining disturb stream banks, but it can also be a source of acid mine drainage and sulfates. See aerial photo from 1987 in Appendix C.

2.2 Sandy Creek Site Descriptions

Two sampling locations were selected for this study. Sample stations were located in Putman County (see map Appendix B). The average width and discharge measurements

in cubic feet per second (**cfs**) during both survey periods are given for each Sandy Creek sampling station in Table 1.

The sample stations are typical of the northern portion of the Central Plains/Grand/ Chariton EDU with steep banks, predominantly sand bottom with some fine silt, and little if any rock or gravel substrate.

Sandy Creek Station #1 (NW ¼ sec. 29, T. 66 N., R.17 W.) is located just downstream of the first small tributary entering the creek downstream of the Highway YY crossing in Putman County. Geographic coordinates at the upstream terminus of this station are UTM Grid 15, East 513720, and North 4483029.

Sandy Creek Station #2 (E ½ sec. 19, T. 66 N., R. 17 W.) is located just upstream of the Calamint Road crossing in Putnam County. Geographic coordinates at the downstream terminus of this station are UTM Grid 15, East 512855, and North 4484205.

Table 1
Sandy Creek Physical Characteristics of the Stations

Sandy Creek Station #	Average Width (feet)	Fall 2007 Flow (cfs)	Spring 2008 Flow (cfs)
1	28	0.08	2.20
2	14	0.07	0.77

3.0 Methods

Sampling at Sandy Creek was conducted in the fall on September 17, 2007 and in the spring on March 27 and April 1, 2008. Sampling was conducted by Brian Nodine and Mike Irwin of ESP. Sampling consisted of macroinvertebrate collection and water quality sampling. Habitat assessments and quantitative channel measurements on Sandy Creek as well as a BIOREF station on Locust Creek were conducted during the fall 2007 sampling season.

3.1 Habitat

Row crop agriculture land use can be associated with instream habitat problems. These problems are often the result of erosion, sedimentation, hydrologic changes, and channelization. Although instream habitat features can be directly measured, the causes of habitat degradation are difficult to pinpoint and can range from local to watershed scale sources. For this study, habitat measurements were collected at the watershed, reach, and local scales to facilitate assessment of the causes of poor habitat conditions.

3.1.1 Land Use

Land cover data were derived from the Thematic Mapper satellite data from 2001-2004 and interpreted by the Missouri Resource Assessment Partnership (**MoRAP**). See Section 2.0 and Table 2 for land use information.

3.1.2 Habitat Assessment

A standardized habitat procedure for Glide/Pool stream types was followed in the Stream Habitat Assessment Project Procedure (**SHAPP**) (MDNR 2003b).

3.1.3 Sinuosity

Sinuosity was used as a rough indicator of the amount of channelization that has occurred. Sinuosity was measured using the National Hydrography Dataset (**NHD**) of the stream segment and is represented as a ratio of the actual stream segment length compared to the straight-line distance between two points. Measurement points were approximately two miles apart with the sampling reach at the center.

3.1.4 Instream Width and Depth Measurements

It is common for streams in northern Missouri to suffer from a lack of instream habitat due to agricultural land use and channelization. These streams trend toward wider channels with shallower water depths and more homogeneous habitat (Haithcoat et al. 2003). At each sampling station a series of ten bank to bank transects were established. Each transect was equally spaced within the sampling reach, which was 20x the average width. Measurements taken at each transect included lower bank width (see SHAPP for a definition of lower bank), wetted width, and water depth at ¼, ½, and ¾ of the distance across the wetted width. To document critical habitat conditions, measurements were collected during the fall low flow period.

3.2 Physicochemical Data Collection and Analysis

During each survey period, *in situ* water quality measurements were collected at all stations for temperature (°C), dissolved oxygen concentration (mg/L), conductivity (µS/cm), and pH. These measurements followed Standard Operating Procedures MDNR-FSS-101 Field Measurement of Water Temperature (MDNR 1993), MDNR-WQMS-103 Sample Collection and Field Analysis for Dissolved Oxygen Using a Membrane Electrode Meter (MDNR 2002b), MDNR-FSS-102 Field Analysis for Specific Conductance (MDNR 2000), and MDNR-FSS-100 Field Analysis of Water Samples for pH (MDNR 2001a) respectively. Additionally, water samples were collected and analyzed by ESP's Chemical Analysis Section (**CAS**) for chloride, total phosphorus, ammonia-N, nitrate + nitrite-N, and total nitrogen. Because of exceptionally high conductivity levels at both stations and considering the history of coal mining in the

watershed, sulfates were also analyzed by CAS. Turbidity (NTU) was analyzed by the WQMS.

Stream discharge in cubic feet per second (**cfs**) was measured at each sampling station using a Marsh-McBirney Flo-Mate Model 2000. Discharge was calculated per the methods in the Standard Operating Procedure MDNR-FSS-113 Flow Measurement in Open Channels (MDNR 2001b).

Physicochemical data were summarized and presented in tabular form for comparison among the two Sandy Creek stations and between sample seasons.

3.3 Macroinvertebrate Collection and Analysis

A standardized sample collection procedure was followed as described in the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP**) (MDNR 2003a). Three standard habitats, non-flowing water with depositional substrate (**NF**), large woody debris (**SG**), and rootmat (**RM**) at the stream edge, were sampled at all locations.

A standardized sample analysis procedure was followed as described in the SMSBPP. The SMSBPP provides details on the calculation of metrics and scoring of the multi-metric Macroinvertebrate Stream Condition Index (**MSCI**). The following four metrics were used: 1) Taxa Richness (**TR**); 2) total number of taxa in the orders Ephemeroptera, Plecoptera, and Trichoptera (**EPTT**); 3) Biotic Index (**BI**); and 4) Shannon Diversity Index (**SDI**).

Macroinvertebrate data were analyzed in three specific ways. First, Sandy Creek stations were compared to biological criteria for the Central Plains/Grand/Chariton EDU. Second, a longitudinal comparison between the two Sandy Creek sites was performed. Finally, a comparison was made of Sandy Creek data between fall and spring sampling seasons. See Tables 10 and 11 for biological criteria for warm water reference streams in the Central Plains/Grand/Chariton EDU for the fall and spring.

4.0 Quality Assurance/Quality Control (QA/QC)

QA/QC procedures were followed as described in pertinent Standard Operating and Project Procedures.

5.0 Data Results and Analyses

5.1 Land Use

According to MoRAP land cover files (see Table 2), the watershed land use of Sandy Creek is comprised mostly of grassland followed by cropland with some forest. A very small area of the land in the Sandy Creek drainage is urban, wetland, or open water. The

majority of land use of the two reference watersheds is grassland followed by cropland and forest.

Table 2
Percent Land Cover

	14-digit HUC	Urban	Cropland	Grassland	Forest	Wetland	Open Water
Central Plains/Grand/Chariton Drainages EDU	NA	2	28	45	18	-	-
Sandy Creek Sites #1 and #2	10280201110003	1	13	52	29	0	1

5.2 Habitat Assessment

Habitat assessment scores were recorded for each sampling station. Results are presented in Table 3. According to the project procedure guidance, the total score from the physical habitat assessment of the study sites should be at least 75% of the total score of the habitat assessment(s) of a BIOREF station(s) to support a similar biological community. Habitat scores for the two Sandy Creek stations were compared with a Locust Creek BIOREF station habitat assessment conducted the same season. Both Sandy Creek stations exceeded the 75% threshold so it is therefore inferred that based on habitat scores, they should support comparable biological communities.

Table 3
Habitat Scores (Fall 2007)

BIOREF Stream	Habitat Score	Sandy Creek Station #	Habitat Score	% of Locust Cr. BIOREF
Locust Creek	107	1	113	106
		2	106	99

5.3 Sinuosity and Riparian Zone Condition

Characteristics for each sampling station are listed in Table 4. Sinuosity was calculated for each station by choosing points on the river approximately two miles apart, with the sampling station in the approximate center of the reach. Sinuosity ratios are calculated by comparing the stream distance between two points to the direct spatial distance between the same two points. The higher the sinuosity ratio, the less likely the stream segment is channelized. The sinuosity ratio was 1.04 on the BIOREF Locust Creek station, indicating a likelihood of channelization. A visual assessment of the map of Locust Creek indicates intense historic channelization throughout much of its length. Sandy Creek sinuosity scores were 1.31 and 1.12 at stations #1 and #2 respectively, indicating a lesser likelihood of channelization. A visual observation of a map of Sandy Creek does not indicate channelization.

Riparian zone conditions derived from SHAPPs conducted in the fall at Sandy Creek ranged from poor at station #2 to very good at station #1. Riparian zone conditions at the Locust Creek BIOREF station were also very good.

Table 4
Sinuosity and Riparian Zone Condition

Station	Sinuosity	Likely to be channelized	Riparian Zone Condition
Sandy Creek #1	1.31	No	Very Good
Sandy Creek #2	1.12	No	Poor
Locust Creek	1.04	Yes	Very Good

5.4 Stream Width and Depth Measurements

Transect measurements for average channel width (= lower bank width), average wetted width, average stream depth, maximum depth, and standard deviation for depths of Sandy Creek stations are represented in Table 5. Overall average values and ranges from selected BIOREF stations are also presented. These BIOREF stations are the ones used for calculating the biological criteria for Sandy Creek and represent an average of eight stream channel measurements from the Central Plains/Grand/Chariton EDU. Channel width to wetted width and wetted width to depth ratios are also presented. The ratios allow for standardization of channel measurements for longitudinal comparisons. Channel width typically widens as a stream proceeds downstream, but wetted width and depth do not necessarily have the same pattern. These ratios allow channel widths and depths to be compared along a stream reach.

Average channel width measurements for the two Sandy Creek sites were near the lower end (station #1) or well below (station #2) the range of channel widths of the BIOREF stations. Average wetted width measurements were well below the range of the BIOREF stations, and the average depths were shallower than the depths of the BIOREF stations. Overall maximum depth was also typically shallower at Sandy Creek than at the BIOREF stations. All these measurements point toward a smaller stream size for Sandy Creek.

The standard deviations of depths at Sandy Creek were typically lower than those of the BIOREF stations, indicating less heterogeneity of depths at the Sandy Creek stations.

At Sandy Creek station #1, the channel width to wetted width ratio was well above the range for those of the BIOREF stations while the same ratio for station #2 fell well within the BIOREF range. The wetted width to depth ratio at station #1 fell within the range of the BIOREF stations while that ratio for station #2 fell slightly below the lower end of the BIOREF range.

Table 5
Channel Dimensions

Station	Average Channel Width (ft.)	Average Wetted Width (ft.)	Average Depth (ft.)	Maximum Depth (ft.)	Standard Deviation of Depth	Channel Width/Wetted Width	Wetted Width/Depth
Sandy Creek #1	31.40	9.85	0.43	1.30	0.37	3.19	23.00
Sandy Creek #2	13.80	9.60	0.55	2.00	0.42	1.44	17.35
BIOREF*average	42.1	25.8	0.8	2.6	0.67	1.65	32.58
BIOREF*range	31.9-57.0	17.8-40.3	0.7-1.11	1.6-4.3	0.40-1.19	1.41-1.88	17.60-57.96

* All BIOREF Central Plains/Grand/Chariton EDU stations including West Fork Big (Class “C”), East Fork Grand, Spring Creek, Locust Creek, West Locust Creek (Class “C”), No Creek, Marrowbone Creek, and Grindstone Creek. All streams Class “P” unless otherwise indicated.

5.5 Physicochemical Data

In situ water quality measurements and turbidity are summarized in Table 6 (fall 2007) and Table 7 (spring 2008). Mean temperatures at Sandy Creek stations were 16.0°C and 8.2°C in the fall 2007 and spring 2008 surveys respectively.

Conductivity levels were consistent among stations within seasons. The fall season conductivity was noticeably higher. The higher conductivity is possibly due to the historic coal mining in the immediate watershed (See Sec. 2.1). Because of the history of coal mining and elevated conductivity levels, sulfate levels were analyzed as well.

Dissolved oxygen levels were consistent between stations and seasons and did not fall below the Water Quality Standards minimum concentration for warm-water and cool-water fisheries (5.0 mg/L). Typically, dissolved oxygen levels are higher during the spring season when water temperatures are cooler.

Turbidity levels were consistently low between sample stations and seasons.

Table 6
In situ Water Quality Measurements and Turbidity at all Stations (Fall 2007)

Station	Parameter				
	Temp. (ºC)	Diss. O_2 (mg/L)	Cond. (µmhos/cm)	pH	Turb. (NTU)
Sandy Creek #1	18	7.29	1220	7.7	2.13
Sandy Creek #2	17	9.14	1340	7.7	3.33

Table 7
In situ Water Quality Measurements and Turbidity at all Stations (Spring 2008)

Station	Parameter				
	Temp. (ºC)	Diss. O_2 (mg/L)	Cond. (µmhos/cm)	pH	Turb. (NTU)
Sandy Creek #1	7.0	11.12	742	7.4	4.65
Sandy Creek #2	9.5	12.46	714	7.9	6.5

Nutrient, chloride, and sulfate concentrations are presented in Table 8 (fall 2007) and Table 9 (spring 2008). Ammonia results, except at station #1 during the spring season, were below detectable limits during both survey periods. Nitrate + nitrite and total nitrogen concentrations were consistent between stations and seasons. Total phosphorus levels were below detectable limits at both stations during both seasons and chloride levels were consistent between stations and seasons. All chloride levels were below chronic criteria for protection of aquatic life and drinking water supply.

Sulfate combined with chloride levels did not exceed the 1000 mg/L Missouri Water Quality Standards criteria for seven (7)-day Q_{10} low flow of less than 1.0 cfs for the protection of aquatic life (MDNR 2005b).

Table 8
Nutrient, Chloride, and Sulfate Concentrations at all Stations (Fall 2007)

Station	Sample #	Parameter (mg/L)					
		NH_3-N	NO_3+NO_2-N	Total N	Total P	Chloride	Sulfates
Sandy Creek #1	0710271	<0.03	0.02	0.32	<0.01	7.05	476
Sandy Creek #2	0710272	<0.03	0.05	0.42	<0.01	6.21	494

Table 9
Nutrient, Chloride, and Sulfate Concentrations at all Stations (Spring 2008)

Station	Sample #	Parameter (mg/L)					
		NH_3-N	NO_3+NO_2-N	Total N	Total P	Chloride	Sulfates
Sandy Creek #1	0805001	0.05	0.01	0.34	<0.01	9.52	205
Sandy Creek #2	0805002	<0.03	<0.01	0.40	<0.01	11.7	202

5.6 Biological Assessment

5.6.1 Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP)

The SMSBPP evaluation used biological criteria that were calculated for the Central Plains/Grand/Chariton EDU from ESP's Wadeable/Perennial Biological Reference Stream database. See Biological Criteria for Wadeable/Perennial Streams of Missouri (MDNR 2002a) for more explanation. These criteria are listed for fall and spring seasons in Tables 10 and 11 respectively. Macroinvertebrate Stream Condition Index sustainability scores of 20-16 qualify as fully sustaining, 14-10 as partially sustaining, and 8-4 as non-sustaining of aquatic life.

Table 10
Biological Criteria for Warm Water Reference Streams in the Central Plains/Grand/Chariton EDU (Fall Season)

	Score = 5	Score = 3	Score = 1
TR	>52	27-52	<27
EPTT	>8	5-8	<5
BI	<7.3	7.3-8.6	>8.6
SDI	>2.68	1.35-2.68	<1.35

Table 11
Biological Criteria for Warm Water Reference Streams in the Central Plains/Grand/Chariton EDU (Spring Season)

	Score = 5	Score = 3	Score =1
TR	>50	25-50	<25
EPTT	>7	4-7	<4
BI	<7.4	7.4-8.7	>8.7
SDI	>2.52	1.27-2.52	<1.27

5.6.2 Comparisons with Regional Reference Streams in the Central Plains/Grand/Chariton EDU

Macroinvertebrate Stream Condition Indices were calculated for Sandy Creek as derived from biological criteria from Central Plains/Grand/Chariton EDU reference streams. The four metrics, total scores, and MSCI sustainability rankings during fall 2007 and spring 2008 are presented in Tables 12 and 13 respectively.

Table 12
Metric Values and Stream Condition Indices, Fall 2007 Sampling Season

Station #	Sample #	TR	EPTT	BI	SDI	MSCI	Sustainability
1	0703275	46	7	7.4	2.01	12	**Partial**
2	0703276	57	7	7.6	2.15	14	**Partial**

Table 13
Metric Values and Stream Condition Indices, Spring 2008 Sampling Season

Station #	Sample #	TR	EPTT	BI	SDI	MSCI	Sustainability
1	0804004	46	5	7.3	2.30	12	**Partial**
2	0804005	67	7	7.4	2.39	14	**Partial**

5.6.3 Sandy Creek Longitudinal Comparisons

There are no significant differences between MSCI scores and metrics longitudinally for either sampling season when both stations received a “partially” sustainable ranking.

5.6.4 Sandy Creek Seasonal Comparisons

There were no differences in sustainability rankings between seasons. Both Sandy Creek stations received the same MSCI for each season

5.6.5 Macroinvertebrate Percent and Community Composition

Macroinvertebrate taxa richness, EPT taxa, percent EPT relative abundance, and top five dominant families are presented in Table 14 for the fall sampling season and Table 15 for

the spring sampling season. The percent of relative abundance data were averaged from the sum of the three macroinvertebrate habitats (depositional non-flow, woody debris, and rootmat) sampled at each station.

Ephemeroptera was the dominant order at both Sandy Creek stations during the fall sampling season with Caenidae being the dominant family. During the spring sample season, Diptera was the dominant order at both stations with Chironomidae as the dominant family.

Table 14
Fall 2007 Macroinvertebrate Composition (percentages rounded to whole numbers)

Station #	1	2
% Ephemeroptera	51	51
% Plecoptera	0	0
% Trichoptera	0	2
Total EPT %	51	53
% Diptera	38	28
% Top Five Dominant Families		
Caenidae	51	49
Chironomidae	36	27
Hyalellidae	8	12
Ceratopogonidae	2	
Physidae	1	2
Hydroptilidae		2

Table 15
Spring 2008 Macroinvertebrate Composition (percentages rounded to whole numbers)

Station #	1	2
% Ephemeroptera	24	27
% Plecoptera	1	0
% Trichoptera	1	0
Total EPT %	26	27
% Diptera	66	57
% Top Five Dominant Families		
Chironomidae	63	55
Caenidae	24	27
Hyalellidae	3	10
Tubificidae	2	1
Ceratopogonidae	1	
Enchytraeidae		1

6.0 Discussion

Physicochemical results revealed few definitive trends other than higher than typical conductivity levels during the fall sampling season. There are no definitive water quality parameters measured during this study that explain the failure of the macroinvertebrate communities to score "fully" sustainable rankings.

As mentioned in Section 2.1, the Sandy Creek watershed has a history of coal mining. For the most part, reclamation appears to be successful with the stabilization of stream banks and no apparent acid mine drainage based on field pH results. However, some sulfate contribution appears to persist even though it is well below the criteria for protection of aquatic life for sulfate combined with chloride levels. An attempt to search for sources of information linking sulfates at the levels found during this study to macroinvertebrate impairment was unsuccessful, therefore it cannot be concluded that the sulfates persisting in Sandy Creek are a source of the low MSCI scores.

Habitat assessments and measurements provide a mix of conclusions that can be drawn. The SHAPP scores for the two Sandy Creek stations fall above the 75% threshold when compared to the BIOREF SHAPP score. In spite of these SHAPP scores, instream habitat for the Sandy Creek stations was very limited. Much of the stream substrate was predominantly bare sand with little structure. During the spring sampling season, the sand substrate was highly unstable and loose likely due to previous heavy rains and runoff.

Channel measurements indicate a smaller stream in comparison with the BIOREF stations, with Sandy Creek having notably narrower and shallower wetted channel. Sandy Creek is a Class "C" stream that is being compared with mostly class "P" streams as biological criteria reference. The smaller stream size and limited habitat is one possible factor that could affect macroinvertebrate communities, especially when compared with larger more permanently flowing streams.

One other factor that could have limited macroinvertebrate communities was the relatively dry conditions just prior to the fall sample season and the high flow conditions during and prior to the spring sampling season. The dry conditions could have further limited habitat in the fall and the high flow conditions during the spring could have caused a scour event(s) that can depopulate macroinvertebrate communities, especially where stable habitat for refuge is limited.

7.0 Conclusions

Based on this study, there may be a conclusion drawn that Sandy Creek is biologically impaired by unknown source(s). From the information in this study, limited habitat appears to be a likely source of biological impairment. However, small stream size may also be a factor in this biological assessment.

8.0 Recommendations

It is recommended that Sandy Creek continue to be monitored biologically, preferably compared with potential future biological criteria derived from similar size class streams.

9.0 Summary

- The null hypothesis that macroinvertebrate assemblages are similar between Sandy Creek and BIOREF streams in the same EDU is rejected.
- The null hypothesis that macroinvertebrate assemblages are similar between Sandy Creek stations is accepted.
- The null hypothesis that macroinvertebrate assemblages are similar between the two sample seasons is accepted.
- The null hypothesis that habitat quality is similar among Sandy Creek stations is accepted.
- The null hypothesis that habitat quality is similar between Sandy Creek and biocriteria reference streams is rejected. The rejection of this null hypothesis is based on channel measurements that indicate Sandy Creek is considerably narrower and shallower.

10.0 Literature Cited

Haithcoat, T.L., M.A. Urban, C.F. Rabeni, and K.E. Doisy. 2003. Biophysical evaluation of reference streams in Missouri: Final report for the Missouri Department of Natural Resources. University of Missouri-Columbia, Missouri 65211. 87 pp.

Missouri Department of Natural Resources. 1993. Field Measurement of Water Temperature. MDNR-FSS-101. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 2 pp.

Missouri Department of Natural Resources. 2000. Field Analysis for Specific Conductance. MDNR-FSS-102. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 15 pp.

Missouri Department of Natural Resources. 2001a. Field Analysis of Water Samples for pH. MDNR-FSS-100. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 10 pp.

Missouri Department of Natural Resources. 2001b. Flow Measurement in Open Channels. Standard Operating Procedure MDNR-FSS-113. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 9 pp.

Missouri Department of Natural Resources. 2002a. Biological Criteria for Wadeable/Perennial Streams of Missouri. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 32 pp.

Missouri Department of Natural Resources. 2002b. Sample Collection and Field Analysis for Dissolved Oxygen Using a Membrane Electrode Meter. MDNR-FSS-103. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 13 pp.

Missouri Department of Natural Resources. 2003a. Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure. MDNR-FSS-030. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 24 pp.

Missouri Department of Natural Resources. 2003b. Stream Habitat Assessment Project Procedure (SHAPP). MDNR-FSS-032. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 40 pp.

Missouri Department of Natural Resources. 2005a. Channel Modification Analyses of Streams Listed on the 303(d) List for Sediment from Non-point Agriculture. Missouri Department of Natural Resources, Environmental Services Program, Jefferson City, Missouri. 6 pp.

Missouri Department of Natural Resources. 2005b. Title 10. Rules of Department of Natural Resources Division 20-Clean Water Commission, Chapter 7-Water Quality. 10 CSR 20-7.031 Water Quality Standards. Missouri Department of Natural Resources, Water Pollution Control Program, P.O. Box 176, Jefferson City, Missouri 65102. pp. 1-135.

Submitted by: _____

Brian L. Nodine
Environmental Specialist III
Water Quality Monitoring Section
Environmental Services Program

Date: _____

Approved by: _____

Alan Reinkemeyer
Director
Environmental Services Program

AR:bnt

c: Irene Crawford, Regional Director, NERO
John Ford, QAPP Project Manager, WPP

Appendix A

Proposed Bioassessment Study Plan
Sandy Creek
July 24, 2007

Missouri Department of Natural Resources
Bioassessment Study Plan
Sandy Creek, Putnam County
July 24, 2007

Objective

This study will characterize the macroinvertebrate communities in Sandy Creek at two sites within the 3 miles of 303(d) listed section to determine if the stream is impaired and justifies continued 303(d) listing. The objective of this study is to determine if aquatic macroinvertebrate life is impaired along the listed section of Sandy Creek.

Null Hypotheses

1). Macroinvertebrate communities in Sandy Creek will not differ significantly from macroinvertebrate communities in similar sized reaches of reference streams within the Central Plains/Grand /Chariton Ecological Drainage Unit (**EDU**).

2). Macroinvertebrate communities will not differ significantly between the two longitudinally separate reaches of Sandy Creek

3). Macroinvertebrate communities will not differ significantly between the two sample seasons.

Background

Sandy Creek begins just south of Mendota in northeastern Putnam County and flows southeast to its confluence with Shoal Creek northwest of Glendale. A three (3) mile segment from Sec. 19, T 66 N, R 17 W to NE Sec. 28, T 66 N, R 17 W (see attachment) is listed on the 303(d) list as impaired by unknown causes. Streams may become listed by U. S. Environmental Protection Agency (**EPA**) for unknown causes for a variety of reasons. The goal of this study is to evaluate the listed segment of Sandy Creek for impairment. If impairment is not demonstrated, rationale will be provided for removing Sandy Creek from the 303(d) list.

Study Design

General: Two Sandy Creek stations will be surveyed. The site locations are: Station 1) just below the tributary downstream of the Highway YY crossing with GPS coordinates Lat. 404973, Long. –92856 at the upstream terminus. 2) Just upstream of the Calamint Road crossing with GPS coordinates at Lat. 40.50846, Long. –92.84827 at the downstream terminus.

At each station, the length sampled will extend 20 times the average stream width as outlined in MDNR-WQMS-032 (MDNR 2003b). To assess comparability between sampling stations and reference streams, stream discharge, habitat assessment and water chemistry will be determined during macroinvertebrate surveys. Sampling will be conducted during the fall of 2007 (mid September through mid October) and the spring of 2008 (mid March through mid April).

Biological Sampling Methods: Macroinvertebrates will be sampled as per the guidelines of the Semi-Quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP**) (MDNR 2003a). Sandy Creek will be considered a "glide/pool" predominant stream; therefore samples will be collected from flow over depositional (non-flow), root-mat, and wood debris (snag) habitats. Each macroinvertebrate sample will be a composite of six subsamples, except for woody debris, which is a composite of twelve.

Habitat Sampling Methods: A standardized habitat procedure for Glide/Pool stream types will be followed in the Stream Habitat Assessment Project Procedure (**SHAPP**) guidelines of MDNR-FSS-032 (MDNR 2003b). Stream channel dimensions will also be measured at each sampling station where a series of ten bank to bank transects will be established. Each transect will be equally spaced within the sampling reach, which was 20x the average width. Measurements taken at each transect will include lower bank width (see SHAPP for a definition of lower bank), wetted width, and water depth at 1/3, ½, and 2/3 of the distance across the wetted width.

Water Quality Sampling Methods: Stream discharge will be measured at each sampling location using a Marsh-McBirney flow meter. Water samples from all sampled stations will be analyzed at the ESP laboratory for ammonia, nitrogen as NO_2 +NO_3, total nitrogen, total phosphorus, chloride and turbidity. Field measurements will include pH, conductivity, temperature and dissolved oxygen.

Laboratory Methods: All samples of macroinvertebrates will be processed and identified per MDNR-FSS-209, Taxonomic Levels for Macroinvertebrate Identification (MDNR 2005). Turbidity samples will be analyzed at the MDNR biological laboratory.

Data Recording and Analyses: Macroinvertebrate data will be entered in a Microsoft Access database in accordance with MDNR-WQMS-214, Quality Control Procedures for Data Processing (MDNR 2003c). Data analysis is automated within the Access database. Four standard metrics are calculated according to the SMSBPP: Total Taxa (TT); Ephemeroptera, Plecoptera, Trichoptera Taxa (EPTT); Biotic Index (BI); and the Shannon Index (SI) will be calculated for each reach.

Macroinvertebrate data will be analyzed in two ways. First, a longitudinal comparison between the three Sandy Creek reaches will be performed. Secondly, the data from the Sandy Creek sites will be compared to biological criteria from wadeable/perennial reference streams with similar geology and watershed size classification.

Data Reporting: Results of the study will be summarized and interpreted in report format.

Quality Control: As stated in the various MDNR Project Procedures and Standard Operating Procedures.

References:

Missouri Department of Natural Resources. 2003a. Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure. MDNR-FSS-030. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 24 pp.

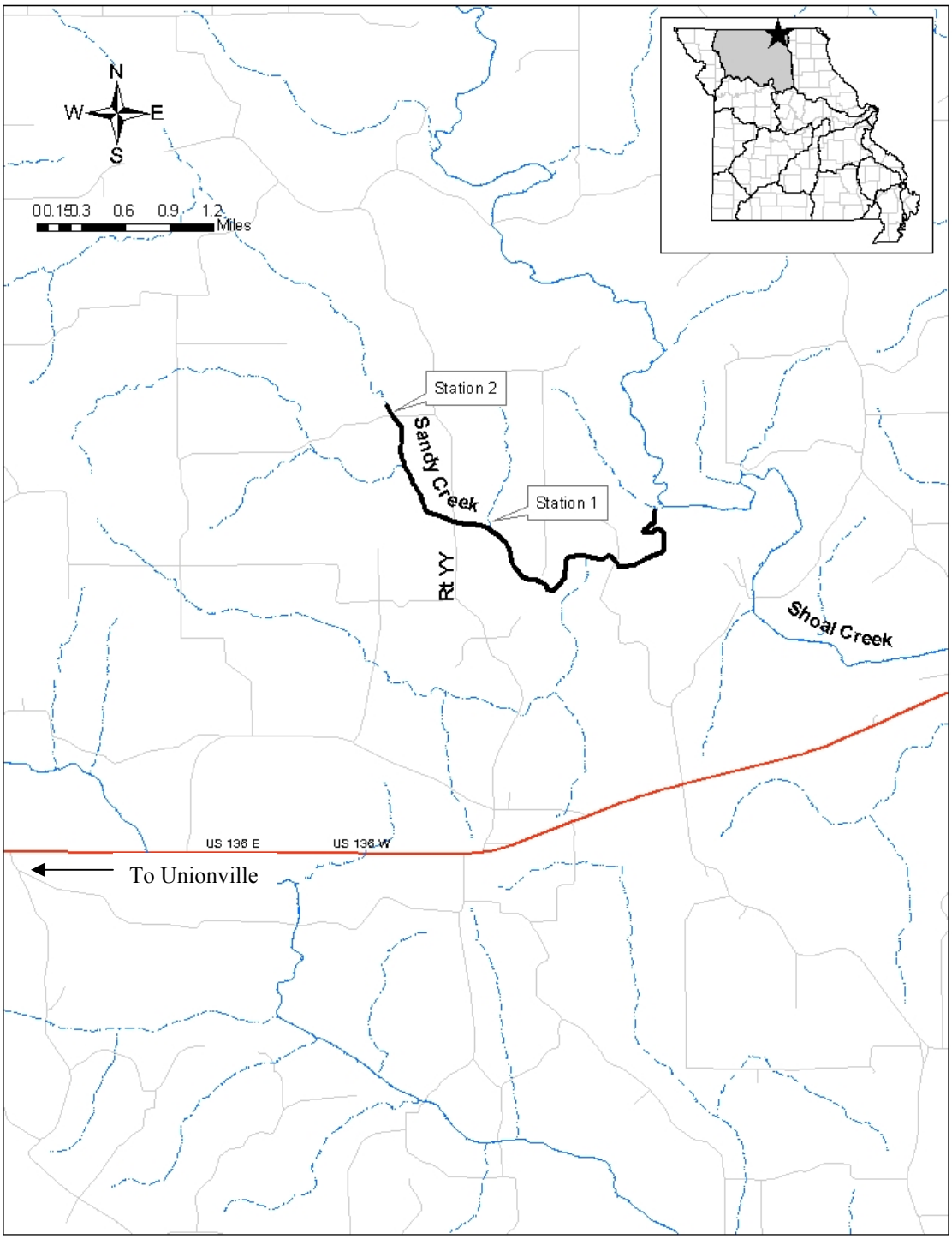
Missouri Department of Natural Resources. 2003b. Stream Habitat Assessment Project Procedure (SHAPP). MDNR-FSS-032. Missouri Department of Natural Resources, Environmental Services Program, P.O. Box 176, Jefferson City, Missouri 65102. 40 pp.

Missouri Department of Natural Resources. 2005. Taxonomic Levels for Macroinvertebrate Identifications. MDNR-WQMS-209. Missouri Department of Natural Resources, Environmental Services Program, P. O. Box 176, Jefferson City, MO 65102. 30 pp.

Missouri Department of Natural Resources. 2003c. Quality Control Procedures for Data Processing. MDNR-WQMS-214. Missouri Department of Natural Resources, Environmental Services Program, P. O. Box 176, Jefferson City, MO 65102. 6 pp.

Bioassessment Study Plan Attachments

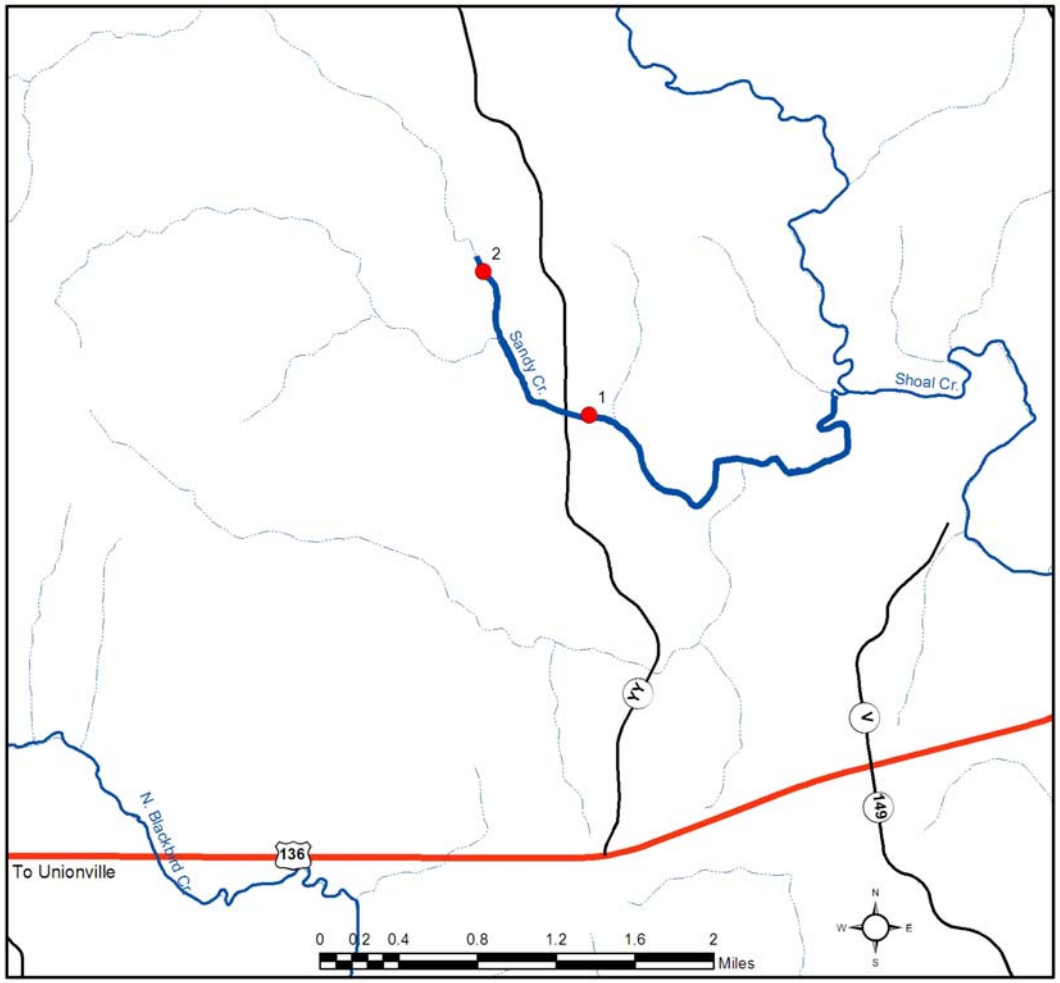
Map of all sampling stations in this study


N
W
E
S
0 0.15 0.3 0.6 0.9 1.2
Miles
Station 2
Sandy Creek
Station 1
Rt YY
Shoal Creek
US 136 E
US 136 W
To Unionville

Appendix B

Sandy Creek Study Area Map

Sandy Creek Study Area



- Bioassessment Sites
- Impaired Streams (2002)
- Classified Stream
- Unclassified Streams
- Missouri Highway
- US Highway

Ecolocial Drainage Unit (EDU)

An EDU is an area that contains a unique combination of habitats and organisms. Missouri is divided into 19 EDUs as shown in the inset map below. This site is located in the highlighted EDU.

Ecological Drainage Unit

Appendix C

Aerial Photograph of Coal Mining Activity in Sandy Creek Study Area
October 6, 1987
(Photograph courtesy of MDNR Land Reclamation Program)


YY
SANDY CREEK
CALAMINT RD

Appendix D

Sandy Creek Macroinvertebrate Bench Sheets

Aquid Invertebrate Database Bench Sheet Report
Sandy Ck [0703275], Station #1, Sample Date: 9/17/2007 11:00:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
AMPHIPODA			
Hyalella azteca	2	52	19
COLEOPTERA			
Berosus		1	
Scirtidae		1	
DECAPODA			
Orconectes virilis	-99	-99	
DIPTERA			
Ablabesmyia	10	12	6
Anopheles		2	
Ceratopogoninae	7	7	
Cladotanytarsus	6		
Corynoneura		3	
Cryptochironomus	2		
Dicrotendipes	11	1	44
Forcipomyiinae			4
Glyptotendipes	1	2	8
Hemerodromia			1
Labrundinia		3	1
Nanocladius	1	2	
Parachironomus		2	
Paratanytarsus	6	26	4
Phaenopsectra	1	2	1
Polypedilum fallax grp			3
Polypedilum halterale grp	2		
Polypedilum illinoense grp	3	7	10
Polypedilum scalaenum grp	2		
Rheotanytarsus			6
Stenochironomus			20
Tanytarsus	62	25	17
Thienemannimyia grp.		3	
Tribelos	5		
EPHEMEROPTERA			
Caenis latipennis	126	183	148
Caenis punctata			1
Hexagenia	1		
Leptophlebiidae			1
Stenacron			1
HEMIPTERA			
Hebrus			1
LIMNOPHILA			
Helisoma		-99	
Lymnaeidae			2
Physella	1	7	1
ODONATA			
Argia		2	
Dromogomphus		-99	
Erythemis		-99	

Aquid Invertebrate Database Bench Sheet Report
Sandy Ck [0703275], Station #1, Sample Date: 9/17/2007 11:00:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Ischnura		2	
Libellula		-99	
Progomphus obscurus	-99		
TRICHOPTERA			
Hydroptila			1
Oecetis	3		
TUBIFICIDA			
Tubificidae	2	2	1

Aquid Invertebrate Database Bench Sheet Report
Sandy Ck [0703276], Station #2, Sample Date: 9/17/2007
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
AMPHIPODA			
Hyalella azteca	3	110	11
ARHYNCHOBDELLIDA			
Erpobdellidae	-99		
BRANCHIOBDELLIDA			
Branchiobdellida		1	
COLEOPTERA			
Berosus		2	
Dubiraphia	2	1	
Helichus basalis		-99	2
Helichus lithophilus			3
Hydroporus		1	
Scirtidae		2	
DECAPODA			
Orconectes virilis		-99	
DIPTERA			
Ablabesmyia	17	6	2
Anopheles		1	
Ceratopogoninae	4	2	
Cladotanytarsus	10	2	3
Cricotopus/Orthocladius		3	5
Cryptochironomus	1		
Cryptotendipes	3		
Dicrotendipes	13	9	36
Empididae			1
Endochironomus	1		
Forcipomyiinae			1
Glyptotendipes		2	2
Labrundinia		1	
Nilothauma		1	
Paracladopelma	1		
Paratanytarsus	9	19	12
Polypedilum		1	1
Polypedilum illinoense grp	6	32	13
Procladius	1		
Rheotanytarsus	1		4
Simulium	1		
Stenochironomus		1	4
Tanytarsus	15	13	10
Thienemannimyia grp.			1
Tribelos	1	6	1
EPHEMEROPTERA			
Caenis latipennis	270	120	105
Callibaetis	1	9	1
Hexagenia limbata	5		
Paracloeodes			1
Procloeon	1		
Stenacron		1	1

Aquid Invertebrate Database Bench Sheet Report
Sandy Ck [0703276], Station #2, Sample Date: 9/17/2007
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
LIMNOPHILA			
Ancylidae		1	
Physella	1	24	
Planorbella		1	
MEGALOPTERA			
Sialis	1	-99	
MESOGASTROPODA			
Hydrobiidae		1	
ODONATA			
Argia	1	-99	1
Calopteryx			2
Enallagma		3	
Erythemis		1	
Gomphus	4	-99	1
Ischnura	1	3	
Libellula	2	1	
TRICHOPTERA			
Hydroptila			20
TUBIFICIDA			
Limnodrilus hoffmeisteri		1	
Tubificidae		4	
VENEROIDEA			
Sphaeriidae		1	

Aquid Invertebrate Database Bench Sheet Report
Sandy Ck [0804004], Station #1, Sample Date: 3/27/2008 8:50:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
"HYDRACARINA"			
Acarina	2		
AMPHIPODA			
Hyalella azteca	1		19
COLEOPTERA			
Hydroporus	1	1	
Peltodytes	5		
Scirtidae		1	
DIPTERA			
Ablabesmyia		1	
Ceratopogoninae	7	2	
Cladotanytarsus	76	7	
Corynoneura		1	
Cricotopus/Orthocladius	10	74	35
Dicrotendipes	1	1	1
Diplocladius		1	
Eukiefferiella	2		
Forcipomyiinae		1	
Glyptotendipes		1	3
Hemerodromia	1		
Hydrobaenus	62	77	18
Limnophyes		1	
Ormosia	3	1	
Parametriocnemus		6	1
Paratanytarsus	7	10	1
Polypedilum halterale grp	6		
Polypedilum illinoense grp	1		
Polypedilum scalaenum grp	1		
Pseudochironomus	1		
Rheotanytarsus	1		1
Simulium	1		3
Stictochironomus	2		
Tanytarsus	4	2	
Thienemanniella			1
Thienemannimyia grp.	1	1	2
Zavrelimyia	2	2	
EPHEMEROPTERA			
Caenis latipennis	81	72	8
HEMIPTERA			
Corixidae	1		
LIMNOPHILA			
Physella	1	1	
ODONATA			
Calopteryx		-99	
Ischnura	1		
Progomphus obscurus	-99	-99	
PLECOPTERA			
Allocapnia	1	4	

Aquid Invertebrate Database Bench Sheet Report
Sandy Ck [0804004], Station #1, Sample Date: 3/27/2008 8:50:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
TRICHOPTERA			
Cheumatopsyche		1	1
Limnephilidae	1		
Oecetis	1		
TRICLADIDA			
Planariidae		1	
TUBIFICIDA			
Enchytraeidae		4	1
Limnodrilus hoffmeisteri	1		
Tubificidae	10	3	2

Aquid Invertebrate Database Bench Sheet Report
Sandy Ck [0804005], Station #2, Sample Date: 4/1/2008 5:20:00 PM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
"HYDRACARINA"			
Acarina		2	
AMPHIPODA			
Hyalella azteca	22	71	5
COLEOPTERA			
Agabus		-99	
Berosus	1		
Haliplus		1	
Helichus lithophilus		1	
Neoporus	1		
Peltodytes	2	2	2
Tropisternus		-99	
DIPTERA			
Ablabesmyia	1		
Ceratopogoninae	5	2	
Chironomidae	1		6
Chrysops	1	-99	
Cladotanytarsus	42		5
Cnephia			4
Cricotopus bicinctus		1	3
Cricotopus/Orthocladius	9	32	175
Cryptochironomus	2		1
Dicrotendipes	3	1	13
Diplocladius			1
Diptera	1		
Dolichopodidae	1		
Endochironomus	1		
Eukiefferiella		1	
Glyptotendipes			1
Gonomyia	1		
Hemerodromia			1
Hydrobaenus	29	31	72
Labrundinia	1		
Limnophyes	2		
Nanocladius		1	
Ormosia	1		2
Parametriocnemus			1
Paraphaenocladius		2	1
Paratanytarsus	4	6	52
Paratendipes	5		
Phaenopsectra		1	1
Polypedilum convictum			2
Polypedilum illinoense grp	2	2	
Pseudosmittia	1		
Rheotanytarsus			3
Stictochironomus	1	1	
Tanytarsus	1	2	7
Thienemanniella			1

Aquid Invertebrate Database Bench Sheet Report
Sandy Ck [0804005], Station #2, Sample Date: 4/1/2008 5:20:00 PM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Thienemannimyia grp.		2	
Zavrelimyia	3	3	
EPHEMEROPTERA			
Acerpenna		1	
Caenis latipennis	100	126	34
Procloeon		1	
Stenonema femoratum	1		1
HEMIPTERA			
Trichocorixa	1		
LIMNOPHILA			
Fossaria			1
Helisoma		-99	
Physella		3	1
MEGALOPTERA			
Sialis		-99	
ODONATA			
Boyeria		-99	
Calopteryx		3	
Dromogomphus	2	1	
Enallagma		1	
Progomphus obscurus	1		
PLECOPTERA			
Perlesta		2	1
TRICHOPTERA			
Cheumatopsyche			1
Hydropsyche		-99	
TUBIFICIDA			
Enchytraeidae	5	3	1
Limnodrilus claparedianus			1
Limnodrilus hoffmeisteri	2		
Tubificidae	6	1	4